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Agenda Item 4.4: **Elaboration of a recovery plan for harbour porpoises in the North Sea**

Distribution of harbour porpoise (Phocoena phocoena) in the German North Sea in relation to density of sea traffic

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Distribution of harbour porpoise (*Phocoena phocoena*) in the German North Sea in relation to density of sea traffic

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Abstract

Sea traffic as a major human impact in the North Sea gave reason to analyse the distribution of harbour porpoises in the German North Sea in relation to the distribution of ships. Sighting data of both, ships and porpoises from aerial surveys conducted following standard line transect methodology was used to calculate absolute densities of shipping traffic and porpoises in the German North Sea. The study area was divided into grid cells and the respective densities for each cell were determined by number of sightings and actually covered area, calculated from flown distance and effective strip-width (esw). The density patterns were then compared statistically for correlation. Neither ships nor porpoises were found evenly distributed over the study area. A concentration of ships in the south-east and of porpoises in the north west of the German North Sea was obvious. The correlation testing revealed a negative correlation between both densities, hinting on porpoises avoiding areas with dense sea traffic. However, a high number of blank values for either porpoise or ship density in many of the grid cells limited interpretation. This study will continue in 2005 and data on the Baltic Sea will be included. During further investigations it is aimed to include information on acoustic characteristics of ships as well as of other human activities (such as seismic surveys, oil platforms etc.).

Introduction

The North Sea is one of the most intensely exploited marine habitats and thus highly affected by sea traffic. Consequences like discharge, water and noise pollution pose a special threat for porpoises (EVANS 1996). However, direct or indirect effects and especially cumulative effects on porpoises can hardly be quantified (BENKE & SIEBERT 1994, SCHEIDAT & SIEBERT 2003). Even though compared to by-catch and set-net fisheries sea traffic is often treated as a minor threat, its impact on porpoises might be strong (EVANS 1996). EVANS (1994) found that porpoises in Shetland avoided shipping traffic of all sizes and suggested that shipping traffic could cause porpoises to depart an area completely. Studies on other cetacean species have lead to similar results and a variety of negative reactions towards shipping traffic has been found (summary in SIMMONDS ET AL. 2003).

Porpoises of the German North Sea are not evenly distributed (HAMMOND ET AL. 2002, SCHEIDAT ET AL. 2003). The aim of this study was to investigate if this might stand in any relation to the distribution of shipping traffic. Therefore sighting data of both, ships and porpoises, from aerial surveys was used to analyse the respective distributions in the German North Sea. Both distribution patterns were then statistically compared. In this working paper we would like to present first results from aerial surveys conducted from May 2002 to October 2003. The study will continue at least until the end of 2005 and further investigations will include data from the Baltic Sea.

Materials and Methods

Study Area

The study area included the exclusive economic zone as well as the 12 nm zone along the coastline of the German North Sea (Fig. 1). It was divided into 4 sub-strata (A, B, C and D). According to their size (A = 3 903 km^2, B = 11 650 km^2, C = 13 668 km^2, D = 11 834 km^2) each region could be surveyed within one day (3-6 hours).

Survey Design and Data Acquisition

The surveys were conducted following standard line-transect methodology for aerial surveys (HIBY & HAMMOND 1989, BUCKLAND ET AL. 1993). From May 2002 to October 2003 a total of 17 358 km of trackline were surveyed on effort, following a parallel transect design for a high-winged twin engine aircraft ("Partenavia 68") flying at an altitude of 600 ft (182 m) at a speed of 90 to 100 kn (167-186 km/h). The direction of tracks was either north-south or east-west, in order to follow gradients of depth (Fig. 1).

The sighting data was acquired by two observers at the time, each positioned on one side of the aircraft at a bubble window. A third person, the navigator, entered the reported data simultaneously into a notebook equipped with the VOR software (designed by Lex Hiby and Phil Lovell and described in HAMMOND ET AL. 1995) and connected to a GPS. Every 4 seconds the aircraft's position was automatically recorded onto the notebook. Additionally, the position was stored whenever a sighting was reported.

Due to their influence on sighting conditions the environmental parameters sea state, turbidity glare and cloud cover were specified at the beginning of each transect and any changes continually reported. Subjective sighting conditions were defined by each observer as good, moderate, poor or unacceptable and changed in correspondence with changing environmental parameters. Reported information on any animal sighting included species, inclinometer angle, group size, location at or under water surface, number of calves, cue, behaviour, swimming direction and observed reactions to the plane. Any ship sighted within an inclinometer angle of ≥ 20° was recorded, too, and assigned to one of the following eight ship categories: containerships (including tankers and cargo vessels), fishing vessels, ferries, motorboats, military/police vessels, research vessels, sailing boats and "other boats".

Data Analysis

The survey data was summarised for every 4-seconds-interval, coinciding with roughly 200 m of flown distance. For each interval the number of porpoises and ships, the exact distance flown and the effective strip-width (as described in BUCKLAND ET AL. 2001) respectively for porpoises and ships was determined, based on the specific G_0 of the survey team. G_0 was determined using the Hiby and Lovell circle-back method (HIBY & LOVELL 1998).The effective half strip-width for porpoises equalled 0.128 for good conditions and 0.036 for moderate conditions. Data obtained under poor conditions was not included in the analysis. For ships an effective half strip-width of 0.503 was calculated, corresponding to a vertical angle of 20° on the inclinometer. It was assumed that all ships occurring were actually seen within the strip and that none were missed by the observers (G_0 = 1). Finally the absolute densities (animals/ships per surveyed km^2) were calculated.

In order to obtain information on distribution and abundance and to be able to compare the densities of ships and porpoises, the survey area was divided into geographic cells of 10 x 10 km (5.4 x 5.4 nm). For each cell the density of porpoises as well as the density of ships was calculated. The data was then analysed and densities visualised using GIS software (ArcView 3.2).

Based on the geographic grid, the densities of porpoises and ships were compared and statistically tested for correlation by means of a Spearman-rank-correlation. Cells in which neither ships nor porpoises were sighted were not included in the test.

A map on estimated ship density in the German North Sea (KNUST ET AL. 2003) was used to validate density results from our sighting data. The employed map, provided by courtesy of the Federal Environmental Agency (UBA), contained a theoretically calculated distribution of shipping traffic in the German North Sea. The sighting positions were layered for comparison.

Results

Survey effort

Due to the fact, that sighting conditions varied between survey days and areas and sometimes changed within one day, thus making it often impossible to cover an area within a day, the conducted effort differed between areas (Fig. 1). Furthermore, the actually surveyed area was larger for ships (18 517 km^2) than for porpoises (2 580 km^2), because the effective strip-width for ships was wider than that for porpoises and independent of weather conditions.

Alltogether 1 882 porpoises and 229 ships were sighted during all conducted flights on effort. Neither ships nor porpoises were found evenly distributed over the survey area. Figures 2 and 3 reveal the positions and group sizes of sightings. Accumulations of sightings in some areas (e.g. area C) stand in close relation to greater effort within these areas. Only the calculated densities, as shown in figures 6 and 7, show the number of sightings in relation to the effort. The ship sightings revealed, that more than one third of all sighted ships were fishing vessels (Fig 3). They seemed to be most abundant along the North Friesian coastline. Also containerships and sailing boats hold great shares among all ships sighted. Most container ships were sighted along the East Friesian coast in the southern part of the survey area. The comparison with the estimated abundance of ships in the North Sea as worked out by KNUST ET AL. (2003) shows, that most ship sightings occurred in areas with higher estimated densities (Fig 5). This holds especially true for container ships.

As can be seen in figures 6 and 7 almost every grid cell was covered during the survey. Nevertheless, not all cells revealed sighting data, therefore these cells appear left white. The north of the survey area showed the highest densities of porpoises in a large area. Especially the areas off the North Friesian islands Sylt and Amrum revealed a great abundance of harbour porpoises. On the other hand ships seemed to be most abundant around the rivermouths of the rivers Elbe and Weser in the south-east of the survey area. Still, the cells showing the highest densities of ships were found in the North Friesian Wadden Sea.

The results of the Spearman-rank-correlation revealed a significantly negative correlation (N = 337, r_s = -0.604, p< 0.01) between the densities of ships and porpoises.

Discussion

Two main results were obtained from this study. Firstly, it proved reasonable to use line-transect sampling to estimate local abundance of ships. (Since ships are not distributed randomly line -transect sampling could not be used for estimating absolute ship densities for the whole area of the German North Sea). For the first time it was tried to obtain data on ships and porpoises under the same survey conditions and the results show, that in further development this method could provide a means for comparing densities, which would be hardly possible with commonly simulated data on ship distribution.

Secondly the comparison of porpoise and ship density revealed, that areas with a high density of sea traffic are less frequented by porpoises than areas with a low density of sea traffic. While porpoises preferably dwell in the north-east of the survey area, areas with highest ship density were found in the south-east. Merely the Wadden Sea showed relatively high densities for both, ships and porpoises. The results of the correlation test proved that the distribution of porpoises is negatively correlated to the distribution of ships in the North Sea.

Nevertheless, it cannot be derived from these results, that sea traffic is necessarily responsible for these findings. Obviously the results of the correlation testing were based on many grid cells with only data on ship **or** porpoise density, a fact almost providing a negative correlation from the beginning. If these findings had their origin in the fact, that porpoises heavily avoid areas with dense traffic, the influence of those grid cells would be justified. However, the small number of ship sightings in comparison to porpoise sightings suggests, that the results might rather have been dominated by a mass of blank values which can be ascribed to too little effort for true ship density representation. In order to check the validity of the correlation it was afterwards checked, if a correlation was found also between only those cells that contain values for both, porpoise **and** ship density. In this case the correlation lost its significance, although it prevailed as a tendency (N = 63, r_s = -0.135, p = 0.292). Based on another assumption all sailing boats were taken out of consideration, because due to size and little noise they possibly represent the least annoyance for porpoises. The negative correlation then approached the level of significance (N= 58, r_s= -0.231, p= 0.08). Finally these findings might provide a first hint on a possible connection between the densities of ships and porpoises. But similarly they show, that for further investigations the statistical evaluation will have to be rethought. Detailed information on this study can be found in HERR (2004).

Altogether, this investigation can only be seen as a first step to further studies on human influences on harbour porpoises in German waters. In future investigations more data will be collected during the continuing aerial surveys. Data already obtained in 2004 as well as data from 2002 to 2004 from the Baltic Sea will be analysed. Furthermore, all findings shall be put into a broader context by including investigations on other anthropogenic influences, especially noise pollution by oil-platforms or offshore windmill parks, or the effects of sand and gravel exploitation. It is necessary to collate all information in order to obtain a good overview over human disturbances for porpoises in the North and Baltic Sea and therefore a close working together with other institutions involved in the investigation of the marine environment would be favourable during the continuation of this study.

Acknowledgements

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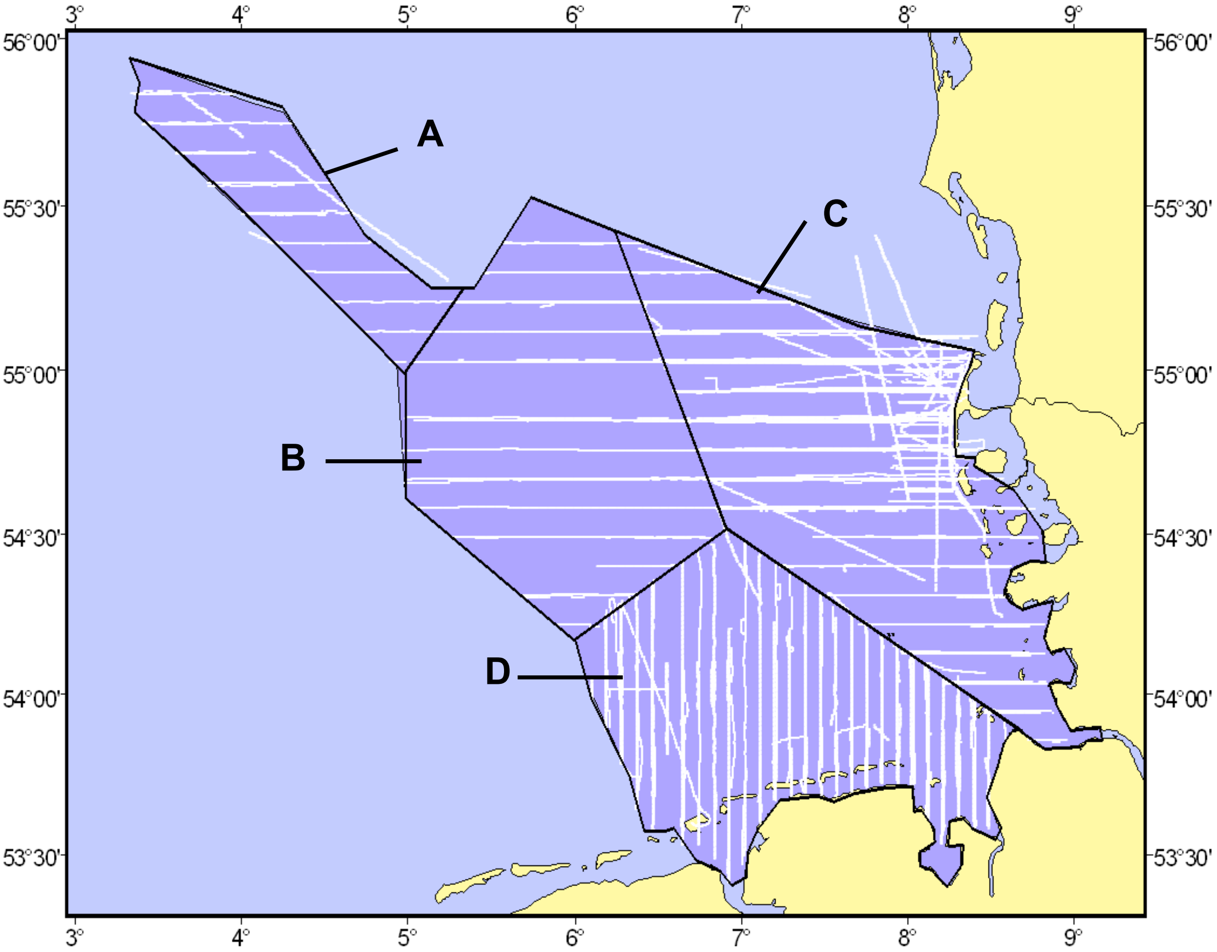

Figure 1: Study area and its division for the aerial surveys in the German North Sea (EEZ + 12 nm zone). The white lines indicate the total number of tracks flown on effort from May 2002 to October 2003. The more often a trackline was surveyed, the thicker it appears in the figure. Projection: Transverse Mercator (UTM 1983; zone 32)

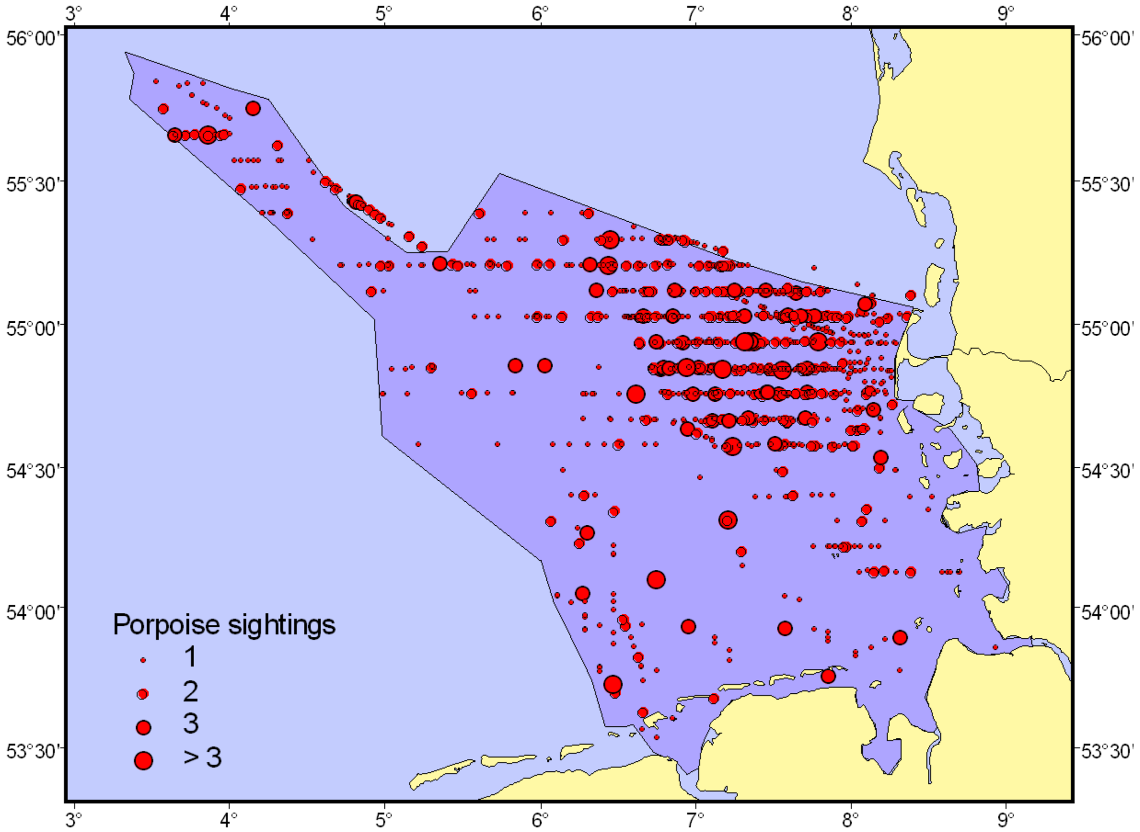

Figure 2: Total number and group sizes of all harbour porpoise sightings in the period May 2002 to October 2003. Projection: Transverse Mercator (UTM 1983; zone 32)

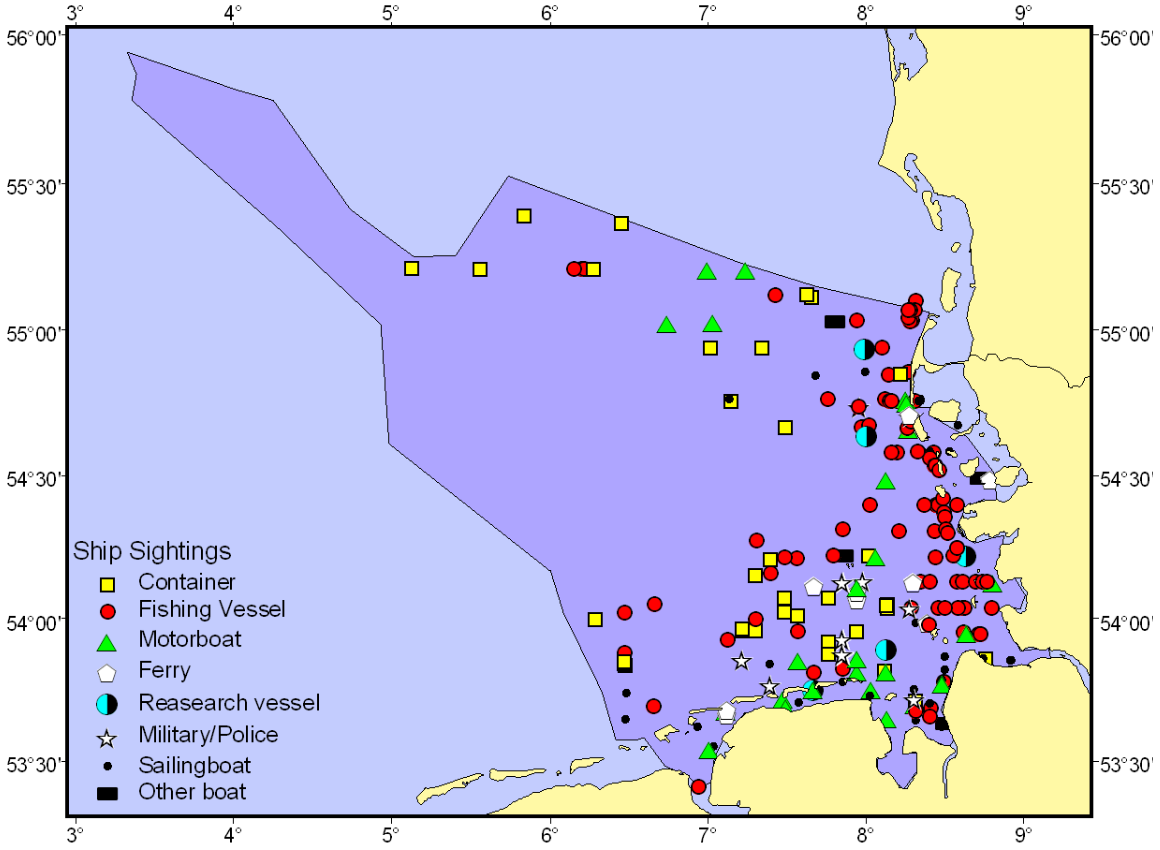

Figure 3: Total number of ship sightings from May 2002 to October 2003 divided into different categories. Projection: Transverse Mercator (UTM 1983; zone 32)

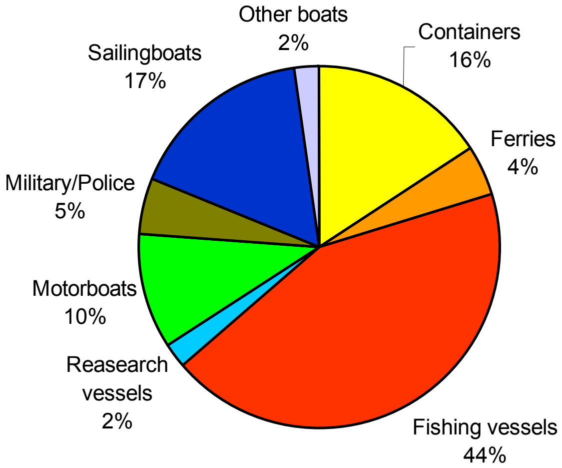

Figure 4: Composition of sea traffic as represented by the sighting data in figure 3.

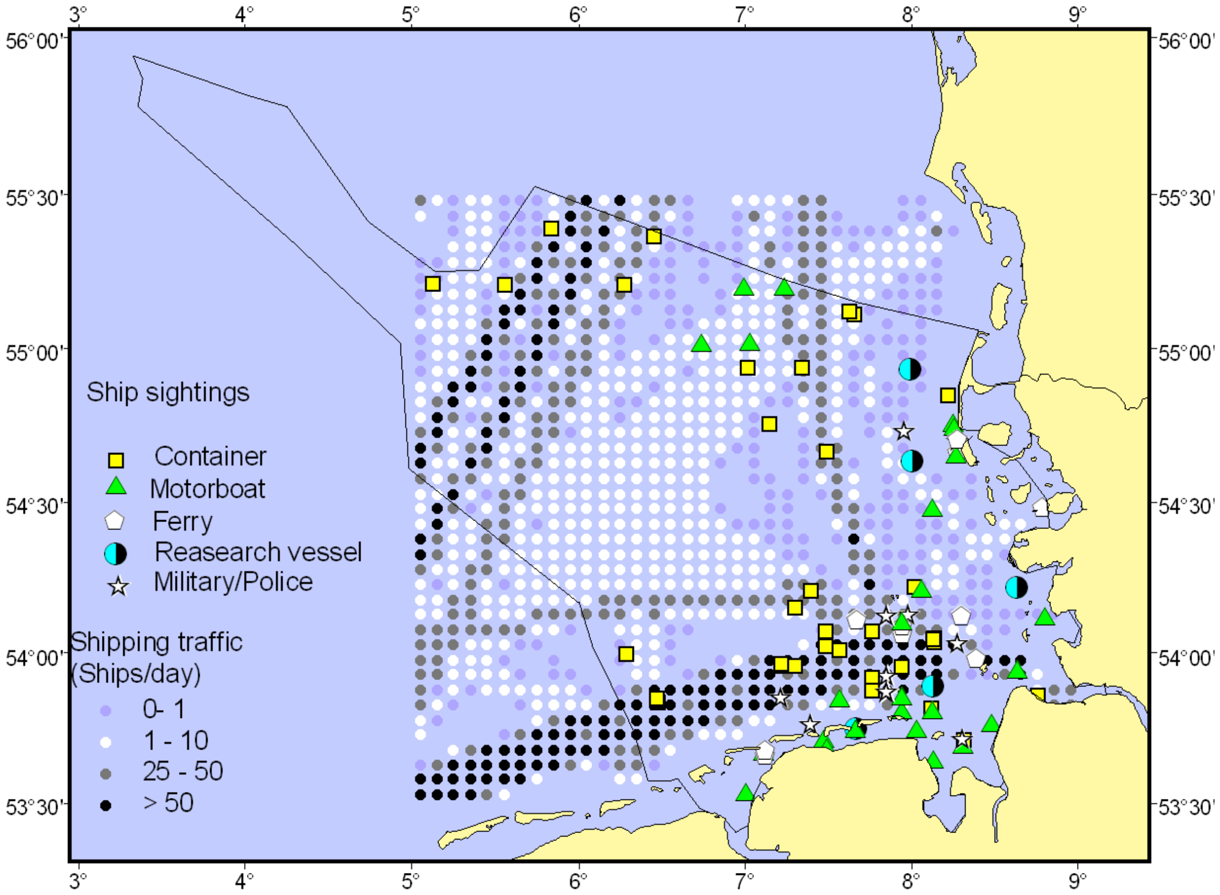

Figure 5: Map on the estimated shipping traffic density per day by KNUST *et al*. (2003). Layed on top are the sightings of all ships except for sailing boats, fishing vessels and "other ships".

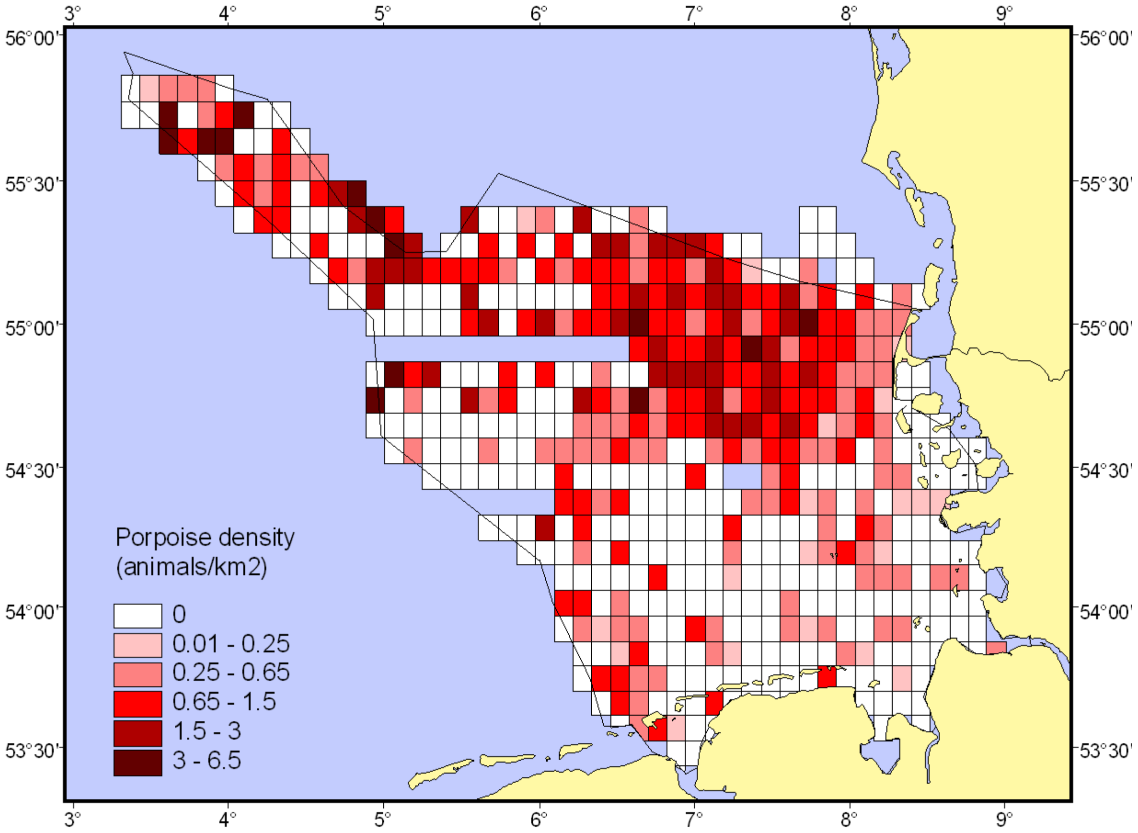

Figure 6: Density of harbour porpoises (animals/km^2) in the German North Sea in the period May 2002 to October 2003. Projection: Transverse Mercator (UTM 1983; zone 32)

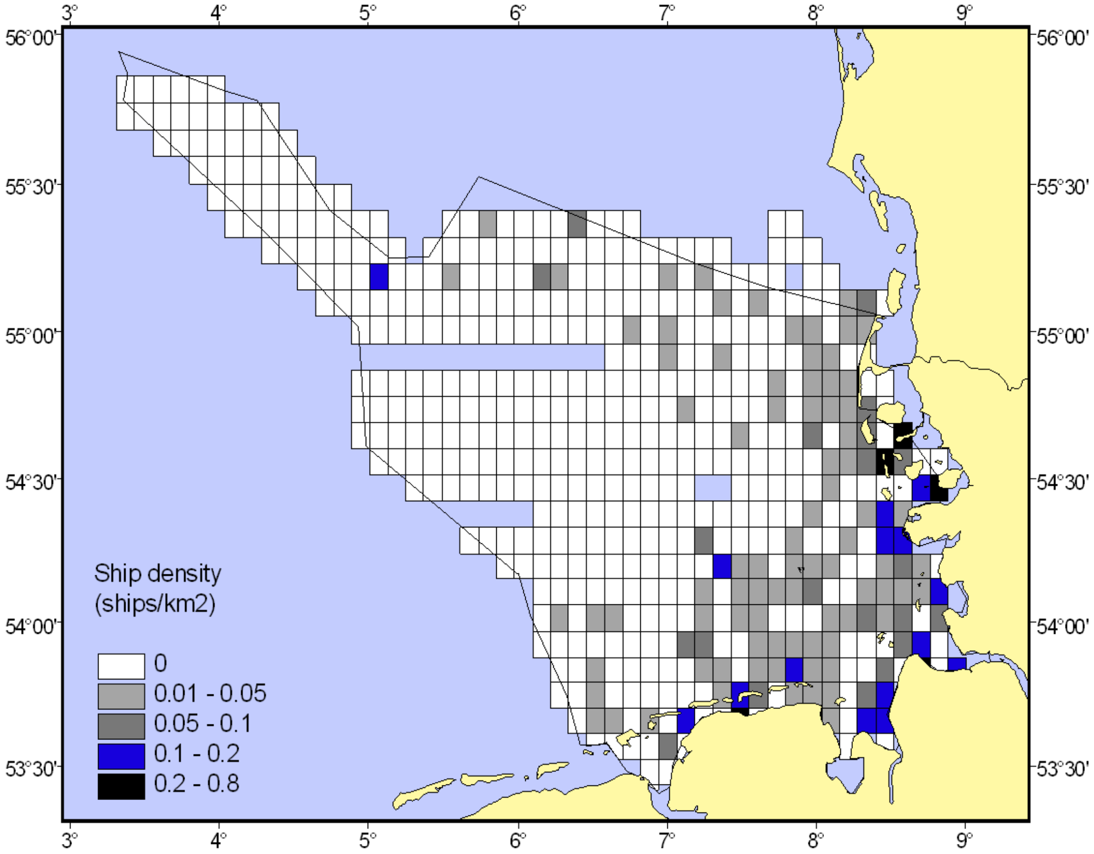

Figure 7: Density of ships (ships/km^2) in the German North Sea in the period May 2002 to October 2003. Projection: Transverse Mercator (UTM 1983; zone 32)